

# *The Recent Evolution of Child Mortality in the Developing World*

## Executive Summary

For the developing world, underfive mortality rates (U5MR, the probability of dying by age 5 per 1,000 live births), relations between mortality in different age segments of childhood, and fragmentary data on causes of mortality in childhood are examined. The U5MR for the median country studied has declined from about 200 in 1960 to a little over 50 in 1990.

Declines have occurred for all regions of the developing world. Rates of decline have increased from approximately 2 percent per year in the 1960s to almost 5 percent per year in the 1980s. Rates of decline have been largest in the East Asia and Pacific regions and smallest in sub-Saharan Africa, though both Latin America and the Middle East and North Africa have performed as well as East Asia and the Pacific since 1975. South Asia has performed better than sub-Saharan Africa, but worse than the other regions. Excellent performance in reducing U5MR during the 1980s was achieved in spite of generally poor economic performance.

As U5MR falls, the concentrations of infant mortality in the neonatal period and of U5MR in the period of infancy both increase. The patterns of change in developing countries in the recent past are very similar to those exhibited in the earlier mortality declines of the industrialized countries. Little is known about cause-of-death patterns in the developing world because of data shortcomings, but a few fragments of data support the contributions of immunization (eliminating neonatal tetanus in the Matlab area of Bangladesh) and oral rehydration therapy (reducing the proportion of childhood deaths in Egypt associated with diarrhea) to reductions in U5MR.

#### The Consultation on Child Survival

On March 7, 1996, nearly 40 representatives of USAID, BASICS (Basic Support for Institutionalizing Child Survival), and other USAID contractors, researchers, and international donor and advocacy groups, including UNICEF, The Rockefeller Fund, WHO, The World Bank, and UNDP, met to discuss achievements in child survival, review common objectives in improving child health, and explore constraints to achieving those objectives. The meeting was sponsored by USAID in cooperation with the BASICS project, and was chaired by **Dr. William H. Foege**, Task Force for Child Survival, Carter Center of Emory University. BASICS coordinated the Policy Advisory Group meeting as part of its role of technical leadership, technical assistance, and support to USAID missions.

In addition to members of the Policy Advisory Group, other panelists at the meeting included:

- **Dr. Pierre-Marie Metangmo**, Johns Hopkins Institute for International Programs
- **Dr. Jacques Baudouy**, Chief, Population and Human Resources Division, Middle East and North African Region, The World Bank
- **Dr. Mary Eming Young**, Early Childhood Development, The World Bank
- **Ambassador Sally Shelton**, Assistant Administrator, Bureau for Global Programs, Field Support and Research Services, USAID

Four background papers were written for the session and are presented in this series, *Current Issues in Child Survival*.

#### Papers in the *Current Issues in Child Survival Series*:

*Review of Child Survival Funding, 1980–95*, by Dr. Deborah McFarland, Emory University

*Accomplishments in Child Survival Research and Programs*, by Dr. Bradley Sack, Dr. Ricardo Rodrigues, and Dr. Robert Black, The Johns Hopkins University

*The Recent Evolution of Child Mortality in the Developing World*, by Dr. Kenneth Hill and Rohini Pande, The Johns Hopkins University

*Overcoming Remaining Barriers: The Pathway to Child Survival*, by Dr. Ronald Waldman, BASICS, Dr. Alfred V. Bartlett, USAID, Dr. Carlos C. Campbell, University of Arizona Health Sciences Center, and Dr. Richard W. Steketee, CDC

#### Policy Advisory Group members:

**Dr. William Foege**, Executive Director, Task Force for Child Survival, Carter Center of Emory University

**Dr. Tomris Türmen**, Executive Director, Family and Reproductive Health, World Health Organization

**Dr. Alan Andreasen**, Associate Dean for Faculty, Georgetown University School of Business

**Dr. Raj Arole**, Comprehensive Rural Health Project, India

**Richard Feachem**, The World Bank

**Dr. Jon Rohde**, UNICEF/India

**Dr. Olive Shisana**, Ministry of Health, South Africa

#### Cataloging-in-Publication Data:

Hill, Kenneth.

The recent evolution of child mortality in the developing world / Kenneth Hill and Rohini Pande. — Arlington, Va. : BASICS, 1997. 12 p. ; 28 cm. — (Current issues in child survival series)

"Prepared for the Senior Consultation on Child Survival meeting held March 7, 1996, sponsored by USAID in cooperation with the BASICS Project."

1. Children—Developing countries—Mortality. 2. Children—Health and hygiene—Developing countries. 3. Infants—Developing countries—Mortality. 4. Infants—Health and hygiene—Developing countries. I. Pande, Rohini. II. BASICS Project. III. Senior Consultation on Child Survival (1997: Washington, D.C.). IV. Title. V. Series.

RJ103.D44H65 1997

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BY KENNETH HILL, PH.D., AND ROHINI PANDE, M.P.A., DEPARTMENT OF POPULATION DYNAMICS, THE JOHNS HOPKINS UNIVERSITY

## Introduction

Substantial resources have been invested in child survival programs over the last decade and a half. If these programs have had the desired effect of reducing child mortality and improving child health, there should be evidence of the effect in child mortality statistics for developing countries. This paper reviews three types of evidence: 1) levels and trends in child mortality since 1960, 2) changes in age patterns of child mortality, and 3) changes in cause patterns of child mortality.

## Levels and Trends in Child Mortality Since 1960

The underfive mortality rate (U5MR, the probability of dying between birth and age 5 expressed per 1,000 live births) is widely recognized as an important indicator of development. It is also the broadest, and hence most inclusive, widely used measure of child survival. Consequently, this section of this paper will focus on changes in U5MR rather than the other commonly used measure, the infant mortality rate. Levels, rates of change, and absolute change in child mortality at the country level over the thirty-year period from 1960 until 1990 are summarized here as box plots<sup>1</sup> for major regions of the developing world and the developing world as a whole. The regions are East Asia and the Pacific, Latin America (including the Caribbean), the Middle East and North Africa, sub-Saharan Africa, and South Asia.<sup>2</sup>

The data used to calculate the child mortality estimates presented here come from a variety of

national censuses and surveys. Data sources include direct and indirect estimates of child mortality from national censuses, prospective population and other surveys, vital registration, and World Fertility and Demographic and Health Surveys. Detailed references for the data sources are given in Hill et al. (1997). Not surprisingly, however, the amount, timeliness, and quality of information available vary widely from one country to another. For example, only one data source, and that from the early 1970s, is available for countries such as Afghanistan, Lebanon, and the Congo. Other countries, such as Bangladesh, Dominican Republic, Egypt, and Turkey, have a number and variety of relatively reliable and recent data sources.

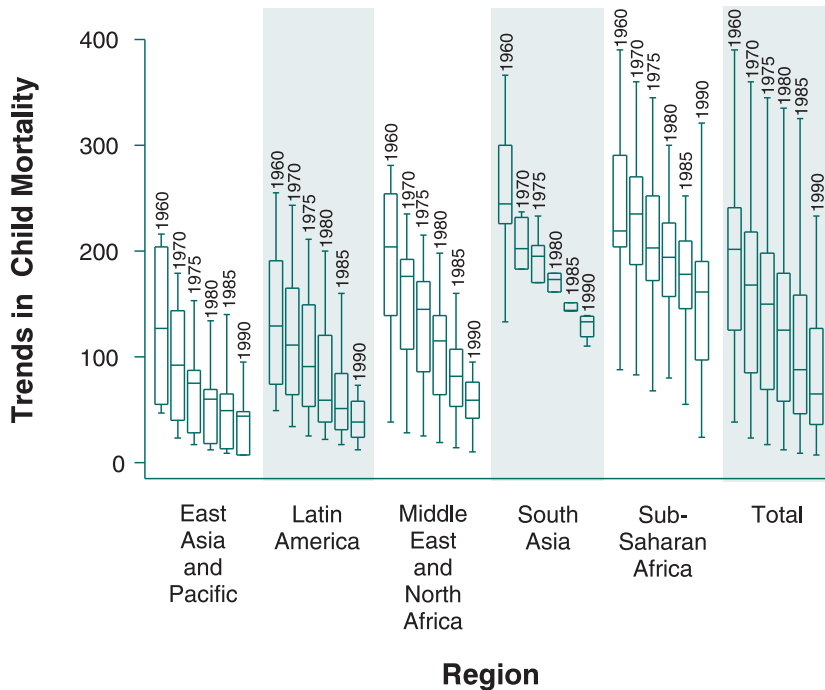
Trends in child mortality have been estimated by fitting a regression line to the relation between observations of U5MR and time for each country, allowing the slope of the line to change when the number of observations permits it, and weighting the observations by subjective assessments of their validity. Estimates have been made in this way for almost 90 developing countries. The methodology is described in detail elsewhere (Hill et al. 1997) and attempts to apply standardized, objective procedures across countries.

Average annual rates of change are calculated as follows:

$$0.2 * (\ln(5q0[n]) / \ln(5q0[n-1])),$$

where  $[n]$  and  $[n-1]$  refer to the  $n$ th five-year period and the five-year period immediately preceding it. The box plots present these rates as percentages.

Figure 1  
Trends in Child Mortality, by Five-year Periods and Region, 1960-90



Absolute changes are calculated as follows:

$$5q0[n] - 5q0[n-1]$$

In this analysis, for each particular time period only those countries that have data points for the time period are included as observations. Thus, countries may join the analysis or drop out of the analysis from one period to another, depending on whether or not data exist for that country in that time period. This raises the question of selection.

Countries could appear in the data set because they are well organized enough to have data. This issue is not considered further.

### Changes in Child Mortality: The Developing World as a Whole

During the last three decades, the developing world as a whole has seen a continuous decline in child mortality in every five-year period between 1960 and 1990. The box plots labeled "Total" in Figure 1 show that child mortality has dropped from an average of about 200 per 1,000 in 1960 to a little over 50 per 1,000 in 1990, with the sharpest declines between 1975 and 1990.

The average annual rates of change in Figure 2 and absolute changes in Figure 3 corroborate this picture. Rates of decline (Figure 2) averaged across the developing world accelerated continuously between 1960 and 1990, and more than doubled from a little under 2 percent in 1960-65 to about 5 percent in 1985-90. The sharpest acceleration was from 1970 to 1985. Figure 3 depicts the absolute changes in child mortality by five-year periods.

For the developing world as a whole, absolute declines in child mortality grew from 1960 until 1980, from a decline of about 18 per 1,000 in 1960–65 to a decline of about 24 per 1,000 in 1975–80. There has been a slowdown in absolute decline in every subsequent five-year period. This finding again supports the picture of improvements in child mortality. Levels of child mortality were already relatively low in 1980, so further absolute declines slowed.

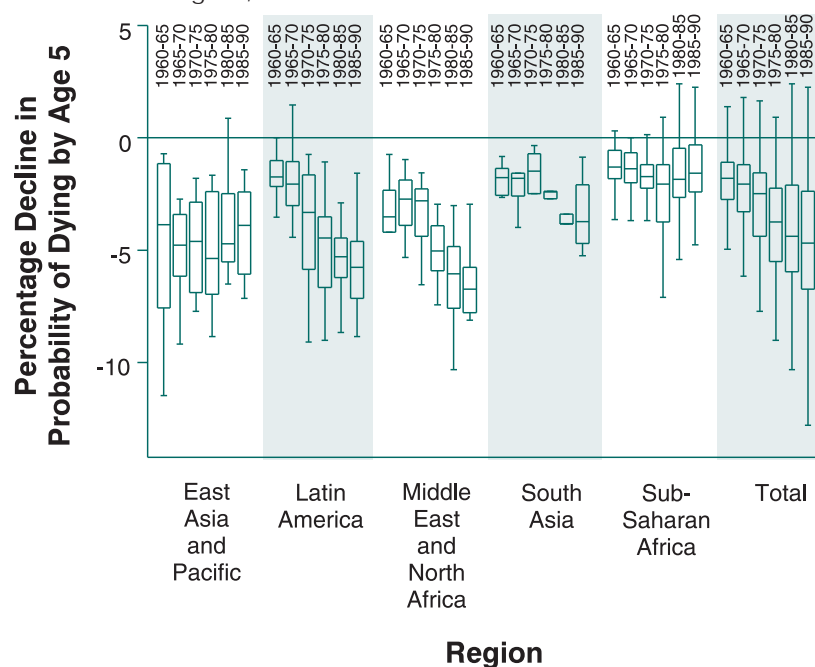
### Changes in Child Mortality: Regional Variations

All regions in the developing world show a systematic decline in levels of child mortality over the thirty-year period. East Asia and the Pacific and Latin America had the lowest regional levels in 1960, at approximately 120–125 per 1,000, and levels fell to about 50 per 1,000 in 1990, again the lowest for the developing world. The most precipitous declines occurred in the Middle East and North Africa, from a high of about 200 per 1,000 in 1960 to a low of just above 50 per 1,000 in 1990, possibly a consequence of rapid economic growth in the Middle East. It is worth noting that rates of decline in this region accelerated sharply after 1975, from an average rate of decline of about 3 percent to rates in excess of 5 percent per year.

South Asia and sub-Saharan Africa continue to have some of the highest levels of child mortality. In South Asia, however, child mortality levels almost halved between 1960 and 1990, from close to 250 per 1,000 in 1960 to about 125 per 1,000 in 1990. Sub-Saharan Africa, on the other hand, showed

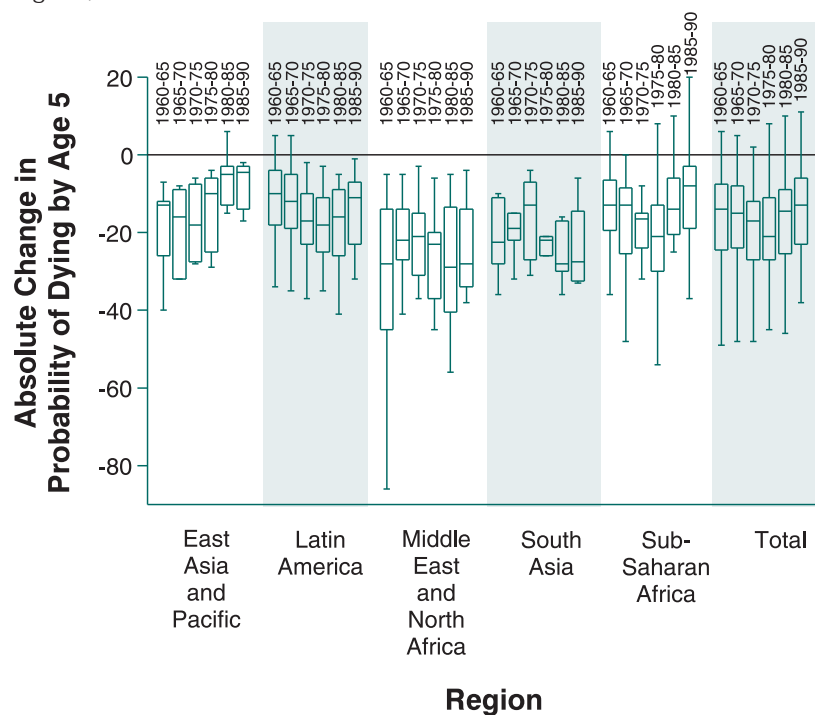
*Figure 2*

Average Annual Rates of Change in Child Mortality, by Five-year Periods and Region, 1960-90



*Figure 3*

Absolute Changes in Child Mortality, by Five-year Periods and Region, 1960-90



much less change: from about 210 per 1,000 in 1960 to 150 per 1,000 in 1990, with a slight increase in mortality levels in 1970.

For the most part, annual rates of change in child mortality by regions for five-year periods show no consistent pattern within regions or across time. East Asia and the Pacific saw the fastest rates of decline in the 1960s, and these rates have remained fairly steady at approximately 5 percent over the thirty-year period. Latin America and the Middle East and North Africa had consistently rising rates of decline, particularly between 1970 and 1990. Rates of decline accelerated the most between 1970 and 1980, and then slowed somewhat thereafter, probably reflecting already low levels of mortality in these two regions. South Asia saw its fastest declines in the period from 1970 to 1985. Sub-Saharan Africa saw hardly any change in rates of decline over the thirty-year period, and continues to have the lowest regional rates of decline in child mortality in the developing world.

As with rates of change, absolute changes generally show no consistent pattern within regions and across time. The exception is East Asia and the Pacific, where the average annual decline in child mortality shrank continuously from 1965 to 1990, reflecting achievement of low levels of child mortality. Latin America had small increases in absolute declines until 1975–80, after which low levels of mortality have meant lower continuing absolute declines. The Middle East and North Africa and South Asia had increasing absolute declines after 1970–75. Sub-Saharan Africa shows

the poorest progress, with accelerating declines until 1980 more or less reversed between 1980 and 1990. For all regions, any acceleration in absolute declines took place before 1980, with a slowdown thereafter. Except for sub-Saharan Africa, and perhaps South Asia, the slowdown in absolute decline is likely to be related to the achievement of relatively low levels of child mortality since 1980.

The overall picture, presented by levels, rates of change, and absolute change in child mortality between 1960 and 1990, is one of rapid progress in child mortality declines in East Asia and the Pacific, Latin America and the Middle East and North Africa to low levels of 50 per 1,000 or less in 1990. South Asia has seen favorable rapid changes since 1980, with a halving of child mortality levels between 1960 and 1990. However, sub-Saharan Africa continues to struggle with high child mortality in most countries for which data are available. Any acceleration of progress in child survival seen until 1980 appears to have reversed since then, and declines in child mortality, in both relative and absolute terms, have recently slowed to near their low levels of the 1960s.

## Age Patterns of Child Mortality

As child mortality changes, its age pattern also changes. In this paper, we will examine two dimensions of the age pattern of child mortality: 1) the proportion of infant mortality (or the probability of dying by age 1) that occurs in the first 28 days, and 2) the relationship between infant mortality and the risk of dying between ages

1 and 5. Mortality risks after the age of 5 are very low.

Typically, as infant mortality declines, the proportion of that mortality that occurs in the first month (neonatal mortality) increases. On the basis of the experience of developed countries, this pattern holds until the infant mortality rate falls to about 20 per 1,000, at which point about three-quarters of all infant deaths occur in the first month.<sup>3</sup>

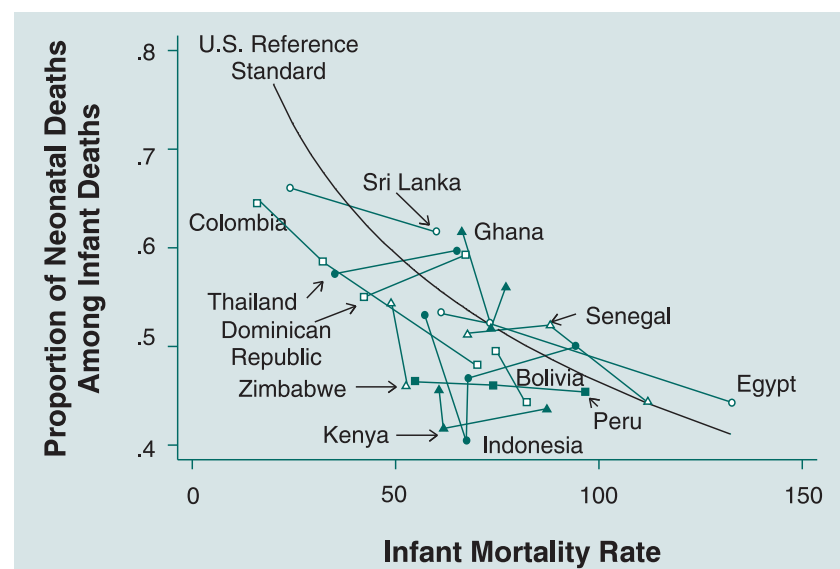
As underfive mortality declines, the proportion of such deaths occurring before age 1 increases. The historical experience of now-developed countries, as expressed in the Coale-Demeny model life tables (Coale and Demeny 1983), indicates four typical patterns for the relationship between infant and child mortality (called the North, South, East, and West patterns by the authors, after the regions of Europe where each pattern was prevalent). In each pattern, the proportion of underfive mortality that occurs before age 1 increases as underfive mortality falls.

In order to examine trends in age patterns of underfive mortality in the developing world, information from 12 countries (four each from Latin America, sub-Saharan Africa, and North Africa plus Asia) with repeated birth history surveys makes it possible to trace age patterns of mortality across time. For ten of the countries, we have used surveys from the World Fertility Survey (WFS, from the late 1970s and early 1980s) and the Demographic and Health Survey (DHS, late 1980s

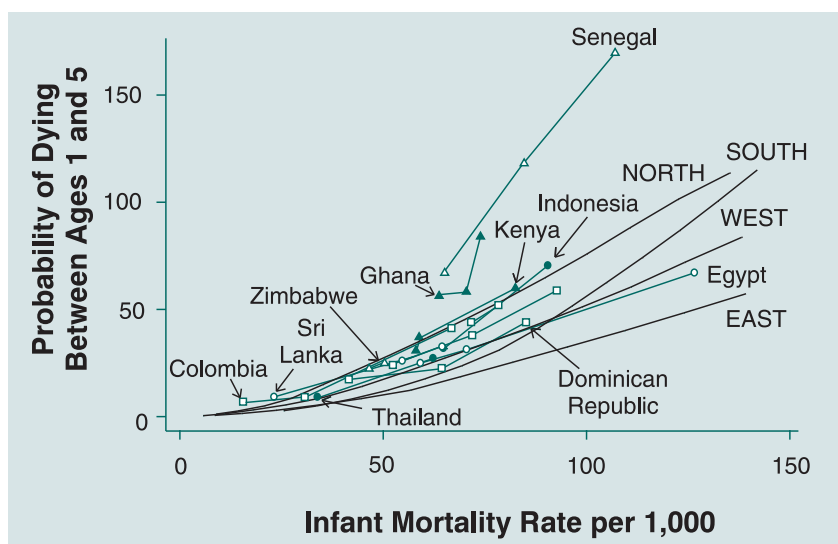
onward). For the remaining two countries, we have used data from repeated DHSs. (References for the sources can be found in Hill et al. 1997.) In all cases, the mortality information is based on experience in the five years before the survey.

Figure 4 shows the proportion of neonatal deaths among all infant deaths, plotted against the infant mortality rate for each country. Also shown is a reference standard based on the vital statistics of the United States from 1915 to 1970. (After 1970, the U.S. pattern changes sharply as the infant mortality rate falls below 20 per 1,000; from 1915 to 1970, however, the relationship between the ratio and the log of the infant mortality rate is close to perfect,  $R^2 > 0.99$ .) There is a substantial amount of erratic

*Figure 4*  
Changes in the Proportion of Neonatal Deaths Among Infant Deaths, by Infant Mortality Rate for 12 Developing Countries



*Figure 5*  
Trends in Probability of Dying Between Ages 1 and 5 Versus  
Infant Mortality Rate for 12 Developing Countries



movement for some countries (notably Ghana and Indonesia), and there are two countries (Thailand and Dominican Republic) in which the proportion of neonatal deaths appears to decline with infant mortality. In general, however, countries appear to follow the pattern of the reference standard (Egypt and Colombia are particularly good examples). Generally, the experience of developing countries in terms of age patterns of infant mortality appears similar to the earlier experience of now-developed countries.

Some indication may be noted from Figure 4 that the proportion of neonatal infant mortality tends to be a bit lower in the developing country sequences than in the reference standard. This pattern may reflect data quality problems, with some omission of neonatal deaths from birth history surveys, even for the period four years or less before the survey.

Figure 5 plots the probability of dying between the ages of 1 and 5 (4q1 in life table notation) against the probability of dying by age 1 for each of the 12 countries. Also shown are the standard patterns from the Coale and Demeny models. In an earlier paper, Hill (1995) has shown that there is substantial variation in age patterns of under-five mortality in the developing world, with very high proportions in infancy in temperate South America and Turkey, and very high proportions between 1 and 5 in tropical West Africa. Figure 5 shows, however, that of the 12 countries examined here, only two (Senegal and Ghana) have age patterns of child mortality clearly different from those of the European historical experience. Both Senegal and

Ghana have much higher mortality between 1 and 5 than would be expected on the basis of their infant mortality. In both cases, the pattern seems to be converging with model patterns as underfive mortality falls.

It is not immediately clear what the effect of child survival interventions would be on the age patterns of underfive mortality. Immunization might be expected to reduce neonatal mortality (tetanus toxoid) and mortality at ages 1 and 2 (measles). Appropriate case management of respiratory infections would probably have its greatest effect in the first three months of life, while case management of diarrhea might have its largest impact in late infancy and the second year of life. Breastfeeding promotion might be expected to have its largest effect on infant mortality, as might child spacing. Micronutrient supplementation, particularly vitamin A, would be expected to have its impact in late infancy and the second year.

The empirical record appears to suggest that the decline in underfive mortality in most parts of the developing world has been following historical patterns quite closely, thus providing no additional evidence for the impact of child survival interventions. The exception is in West Africa, where a historically abnormal pattern is disappearing, possibly as a result of reduction in measles mortality. However, such a conclusion must, in the absence of good data on trends in mortality by cause of death, remain speculative.

## Cause-of-Death Patterns

The use of censuses and surveys, particularly birth history surveys, has greatly improved our knowledge of levels, trends, and age patterns of underfive mortality. However, the absence of accurate civil registration systems in most of the developing world, and the fact that many child deaths occur without the child being seen by a physician, have serious consequences for our knowledge of the causal distribution of deaths of children. Most of what we know, particularly in high-mortality settings, is derived from verbal autopsy reports, which at best can distinguish only a small number of very broad cause-of-death categories. The data on trends are even shakier, since very few examples exist of verbal autopsy reports applied in a comparable way at different time points. One of the longest series comes from the Demographic Surveillance System in Matlab, Bangladesh. Published data on the cause-of-death structure are available beginning in 1980.

However, even in this series, changes in definitions and procedures make the data essentially uninterpretable. Table 1 shows the percentages of deaths from various cause groups for infants and children aged 1 to 4 for the years 1980, 1986, and 1992 (ICDDR, B). The absolute numbers of deaths fall sharply over the period, reflecting steep falls in child mortality in Bangladesh since about 1975. The changes in cause-of-death patterns make no sense. In particular, tetanus deaths in 1980 include “takuria,” or evil eye. There must be some suspicion that the 1986 tetanus deaths also include some such

Table 1  
Cause of Death Data for Children Under Age 5 in Matlab Thana, Bangladesh, 1980, 1986, and 1992

Cause of Death	Infant Deaths			Deaths at Ages 1 to 4		
	1980	1986	1992	1980	1986	1992
Tetanus (%)	55	27	0	5	2	0
Measles (%)	2	2	(NS)	11	11	(NS)
Respiratory (%)	7	22	18	6	10	11
Diarrhea (%)	3	10	14	4	13	33
Dysentery (%)	1	5	1	23	33	5
Drowning (%)	1	1	1	10	12	16
Other (%)	31	33	66	41	19	35
Total Deaths	768	622	497	487	396	196

NS = Not specified separately

category, though the report does not specifically state this category.

The 1980 figure certainly overestimates the true proportion of infant deaths caused by tetanus, and the 1986 figure may also be an overestimate, although other studies in Matlab indicate that the death rate from neonatal tetanus may have been as high as 20 per 1,000 live births. The 1992 figure indicates that neonatal tetanus has been eliminated as a cause of death in the Matlab area, presumably largely because of immunization.

Another example of the application of broadly similar verbal autopsy methodology at different time points comes from Menoufia Governorate in Egypt (Langsten and Hill 1994). From 1979–80 to 1990–91, while the overall mortality rate for children aged 0–4 fell from 44.7 to 11.2 deaths per 1,000 years lived, the proportion of deaths caused by diarrhea fell from 50 percent at the first survey to 41 percent at the second. The time period between the surveys included the activities of the major National Control of Diarrheal Diseases Project. That diarrheal disease fell in terms of its relative contribution to child mortality suggests that the project had some impact (supported by ORS knowledge and use figures). But the fact that, even after the project, two deaths in five were diarrhea-associated indicates that victory was declared too early.

## Conclusions

Underfive mortality risks have fallen rapidly in the developing world during the last 30 years. Whereas

in 1960 the average country with data had a U5MR of about 200, in 1990 the average country with data had a U5MR of little more than 50. Mortality levels in 1990 vary sharply by region, from an average of over 150 in sub-Saharan Africa to 50 or less in East Asia and the Pacific, Latin America, and the Middle East and North Africa.

These differences have arisen in large part from differential performance since 1960. In East Asia and the Pacific, U5MR has fallen at an average of close to 5 percent per year over the entire period, and the Latin America and Middle East declines have been similarly rapid since 1975. In sub-Saharan Africa (and to a lesser extent in South Asia), the annual rates of decline have been on the order of 2 to 3 percent, with no increase in the rate (at least in Africa) in the 1970s.

A recent parallel analysis (Hill et al. 1997) shows that these regional variations in performance persist even when differences in income growth are controlled. Overall, the strong declines in child mortality achieved during the 1980s, a period of slow economic growth in many parts of the developing world, support the view that cost-effective health interventions have contributed to the mortality decline over this period. This conclusion is further supported by fragmentary evidence on cause of death, showing the virtual elimination of neonatal tetanus in a rural area of Bangladesh with high levels of tetanus toxoid immunization, and the reduction of the proportion of childhood deaths associated with diarrhea in a rural area of Egypt following a major oral

rehydration program. The data available are consistent with the contention that primary health care strategies have played an important role in reducing child mortality in the developing world.

## Notes

1. A box plot summarizes the distribution of a variable. The box is a rectangle, the top and bottom of which mark the seventy-fifth and twenty-fifth percentiles, respectively, with the median observation (in this case, the median country) as a cross-bar within the box. The “whiskers” for each box are the lines protruding above and below, and indicate the range of the data above and below the upper and lower quartiles.
2. Regions are grouped according to the country groupings in UNICEF *State of the World's Children 1995*, p 86.
3. As infant mortality falls below 20 per 1,000, however, the pattern reverses, and the proportion in the first month starts to fall again.

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**(Basic Support for Institutionalizing Child Survival)**



A USAID-funded project administered by the Partnership for Child Health Care, Inc.  
Partners: Academy for Educational Development (AED), John Snow, Inc. (JSI), and Management Sciences for Health (MSH)

1600 Wilson Boulevard, Suite 300 ■ Arlington, VA 22209 USA ■ Phone: 703-312-6800 ■ Fax: 703-312-6900  
Internet: [infoctr@basics.org](mailto:infoctr@basics.org)